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Back to results list

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[NAME OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] METHOD AND APPARATUS FOR ASSEMBLING SUBSTRATE

[BACKGROUND OF THE INVENTION]

The present invention relates to method and an apparatus for assembling substrates and more specifically to method and an apparatus for affixing substrates in a vacuum chamber to fabricate a liquid crystal display panel and so forth.

Conventionally, an apparatus for assembling a liquid crystal display panel has been disclosed in Japanese Application Patent Laid-Open Publication No. 2000-284295. An apparatus for affixing substrates, disclosed in Japanese Application Patent Laid-Open Publication No. 2000-284295, applies an adhesive (thereafter also referred to as "sealant") to a substrate according to its shape along the peripheral portions of the substrate and then dispenses liquid crystal within an area confined within the boundaries of the adhesive. Then, in a vacuum chamber, the substrate on which liquid crystal has been dispensed is placed on a table and a counter substrate is vacuum held to a pressurizing plate facing to the substrate below, and subsequently the gap between the substrates is narrowed so that the substrates are pressurized and affixed together. Further, the above-mentioned Japanese Application Patent

Laid-Open Publication has disclosed a method for holding and pressurizing the upper substrate in a vacuum chamber in such a way that, at first the substrate is held in place by a vacuum holding mechanism, and after pressure has been reduced to a specified level, the substrate is held in place by an electrostatic holding mechanism and then pressurized. In this procedure, if pressure continues to decrease while the substrate is being held by a vacuum holding mechanism, the vacuum holding force is reduced causing the substrate to separate from the pressurizing plate and drop on the substrate below. Therefore, to prevent the upper substrate from falling, an apparatus which has movable holding claws that hold the peripheral portions of a substrate in the vicinity of the pressurizing plate, has also been disclosed in the above-mentioned Japanese Application Patent Laid-Open Publication.

Incidentally, when the size of a substrate increases and the thickness is reduced, if the peripheral portions of a substrate only are held as shown in the above conventional example, the center portion of the substrate is deflected downward due to the weight of the substrate itself. As a result, when the pressurizing plate is lowered and pressed onto the substrate, an electrostatic attraction force does not act on the center portion of the substrate, which causes a problem that the substrate cannot

be electrostatically held accurately to the pressurizing plate. Furthermore, even when only the peripheral portions of a substrate are electrostatically held and deflection remains in the center portion of the substrate, in some cases, the substrate is progressively attracted to the pressurizing plate from the peripheral portions toward the center portion. In this case, however, there is a problem that strain remains on a glass substrate that has been held to the pressurizing plate. If strain remains on a substrate, a cell will be easily damaged by slight stress or impact, or the cell's display function as a liquid crystal display panel deteriorates due to a repetitive stress load.

[OBJECT AND SUMMARY OF THE INVENTION]

The main purpose of the present invention is to provide an apparatus and method for assembling substrates which can eliminate the aforementioned problems and accurately assemble substrates without putting strain on substrates even though the size of a substrate is increased and the thickness is reduced.

In order to attain the above purpose, the present invention places a substrate to be affixed on a table located on the underside of a vacuum chamber and also holds a counter substrate to be affixed directly above the substrate below facing to it by a pressurizing plate which

has a vacuum holding mechanism and an electrostatic holding mechanism. Further, in order to prevent the counter substrate, which has been vacuum held to the pressurizing plate under atmospheric pressure, from dropping due to a decreasing vacuum holding force in the process of pressure reduction in a chamber, the present invention provides substrate holding mechanisms that mechanically hold the peripheral portions of the counter substrate. A substrate holding mechanism that holds a pair of opposite sides of the counter substrate has a plurality of holding claws, and among the holding claws, holding claws that hold the middle portions of the substrate edges are set to be higher than other holding claws. This configuration enables the control so that the pressure of the vacuum chamber has been reduced and the substrate is held by holding claws and then the substrate is progressively held from its center portion to the peripheral portions by electrostatic attraction means.

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG.1 is a schematic diagram of a substrate assembling apparatus which is an embodiment of the present invention.

FIG.2 is a top view of a vacuum chamber for the substrate assembling apparatus shown in FIG.1.

FIG.3 is an enlarged view that illustrates the main portions of a holding claw mechanism in the vacuum chamber

shown in FIG.2.

FIG.4 is a configuration diagram that illustrates a table, pressurizing plate and auxiliary claw mechanism in the vacuum chamber shown in FIG.2.

FIG.5 is a plan view of a substrate holding mechanism for another embodiment.

FIG.6 is a cross-sectional view of another substrate holding mechanism for the embodiment shown in FIG.5.

[DESCRIPTION OF THE EMBODIMENTS]

A substrate assembling apparatus which is a first embodiment of the present invention will be described in detail below referring to FIG.1 through FIG.4. FIG.1 is a schematic diagram that illustrates a substrate assembling apparatus according to the present invention, and FIG.2 is a top view of a vacuum chamber for the substrate assembling apparatus shown in FIG.1. FIG.3 is an enlarged view that illustrates the main part of a substrate holding claw mechanism located in the vacuum chamber shown in FIG.2, and FIG.4 is a diagram that illustrates a table, pressurizing plate and substrate holding mechanism located in the vacuum chamber shown in FIG.2.

As shown in FIG.1, a substrate assembling apparatus 100 in accordance with the present invention consists of a stage S1, a substrate assembling section S2, and a Z-axis direction moving stage S3. A frame 2 which supports the

substrate assembling section S2 and a frame 3 which supports the Z-axis direction moving stage S3 are located on a base 1, and the stage S1 is located on the top surface of the base 1.

The stage S1 is equipped with an X stage 4a having a drive motor 5 which allows a Y stage 4b located on the X stage 4a to move in the X-axis direction as shown in FIG.1. Further, the Y stage 4b has a drive motor 6 which allows a θ stage 4c located on the Y stage 4b to move in the Y-axis direction perpendicular to the X-axis and the Z-axis, as shown in FIG.1. Furthermore, a support 9a which supports a shaft 9 is located on the θ stage 4c having a drive motor 8, and the drive motor 8 allows the support 9a to rotate with respect to the Y stage 4b via rotating bearings 7.

A table 10 on which a lower substrate is placed is located on the upper end of the shaft 9. Further, one end of an arm 11 is mounted to the Y stage 4b and the other end is mounted to an airtight holding body 13. The airtight holding body 13 is provided so that it surrounds the shaft 9 via rotating bearings and vacuum seal. The lower end of a vacuum bellows 12 is mounted to the airtight holding body 13. The upper end of the vacuum bellows 12 is mounted to the external wall of a vacuum chamber 14. Such a configuration of the airtight holding body 13 ensures smooth rotation of the shaft 9 as well as excellent

airtightness and prevents the arm 11 and the vacuum bellows 12 from rotating together with the shaft 9 when the shaft 9 rotates.

The substrate assembling section S2 consists of a vacuum chamber 14; a table 10 and a pressurizing plate 15 located in the vacuum chamber 14; a first substrate holding mechanism 40 and a second substrate holding mechanism 60 both of which hold, lift, and lower a substrate as will be described later; and a gate valve 16 located at an inlet/outlet port of the vacuum chamber 14. As shown in FIG.1, the pressurizing plate 15 is mounted to a Z-axis direction moving base 27 via shafts 25. A shaft 25 is enclosed by a vacuum bellows 26. One end of the vacuum bellows 26 is mounted to the external wall of the vacuum chamber 14 and the other end is mounted to the Z-axis direction moving base 27. The vacuum bellows 26 maintains a vacuum state in the vacuum chamber 14.

The underside of the vacuum chamber 14 has a duct 20 for low pressure exhaust from the vacuum chamber 14. The duct 20 is connected to a vacuum pump (not shown) via a switching valve (not shown). Further, a duct 21 and a vent switching valve 22 are located on the upside of the vacuum chamber 14 to convert the chamber from a pressure reduction state to an atmospheric pressure state. Furthermore, the upside of the vacuum chamber 14 has an observation window

23 to look at alignment marks (not shown) so that two substrates can be affixed without dislocation. Through the observation window 23 and a mark recognition hole (not shown) located in the pressurizing plate 15, a recognition camera 24 measures the dislocation of alignment marks for both upper and lower substrates, and based on the obtained measurements, alignments are made to correct the dislocation of both substrates' positions.

Now, the configuration of the vacuum chamber 14 will be described in detail with reference to FIG.4. A table 10 has vacuum-holding ports to vacuum hold a lower substrate B2, and each vacuum-holding port is connected to a vacuum-holding valve (not shown) located outside the vacuum chamber 14 via a duct 17. Furthermore, the table 10 has electrostatic chucks 10a to 10c for electrostatic attraction, and leads for positive electrodes and negative electrodes are drawn out from the vacuum chamber 14.

Moreover, a pressurizing plate 15 also has vacuum-holding ports 18a, 18b, 18c and ducts 19a, 19b, 19c, and vacuum-holding valves (not shown) for each duct are provided outside the vacuum chamber 14. The vacuum-holding range of vacuum-holding ports 18a to 18c is, as shown in FIG.4, divided into three areas corresponding to each port: right, center, left; as seen on the drawing. This configuration allows each vacuum-holding valve to

switch the vacuum-holding area that corresponds to each vacuum-holding port 18a to 18c. Furthermore, ducts 19a to 19c are connected to vacuum vent valves, and opening the valves will restrict or release vacuum-holding areas that hold a substrate.

Moreover, the pressurizing plate 15 has a plurality of electrostatic chucks 15a to 15c which divide the electrostatic holding range into plural areas. Leads for positive electrodes and negative electrodes of the electrostatic chucks are drawn out from the vacuum chamber 14 so that each electrostatic chuck can individually control the electrostatic holding area.

The Z-axis direction moving stage S3 consists of a Z-axis direction moving base 27, linear guides 28, a ball screw 29 and an electrical motor 30, and the Z-axis direction moving base 27 lifts and lowers the pressurizing plate 15.

Furthermore, a control apparatus 80 controls various drive means which include a drive motor 5 through air cylinders 62a and 62b that are provided in the above-mentioned stage S1, substrate assembling section S2 and Z-axis direction moving stage S3.

Next, substrate holding mechanisms for a substrate assembling apparatus in accordance with the present invention will be described with reference to FIG.2 through

FIG.4.

As shown in FIG.2, a first substrate holding mechanism 40 is located on the right and left of a substrate in the vacuum chamber 14, seen from a gate valve 16. Also, a second substrate holding mechanism 60 is located at the front and back of a substrate in the vacuum chamber 14, seen from a gate valve 16.

Now, the configuration of the first substrate holding mechanism 40 will be described. Holding claws (holding bodies) 41a, which are disposed in higher locations than holding claws (holding bodies) 41b by the amount of deflection (shown as "d" in FIG.3) applicable to the upper substrate B1, are mounted to coupling plates 42 respectively. This is, as illustrated by broken lines in FIG.4, for the upper substrate B1 to be held in a convex shape by claws 41a and 41b, as will be described later. In this embodiment, the height of the holding claws 41a is different from that of the holding claws 41b. However, by setting both holding claws 41a and 41b to be at almost the same height and changing vacuum-holding conditions, it is possible to obtain the same result as the case where the upper substrate B1 is held in a convex shape.

A coupling plate 42 is mounted to a linear guide 43 which is mounted to an elevating plate 44 so that it can horizontally move in the direction of the arrow R1 shown

in the drawing. Further, the coupling plate 42 is mounted to a linear guide 46 via a metal fixture 45, and the linear guide 46 is configured to move up and down along a guide plate 47 in the direction of the arrow R2 shown in FIG.3.

The above-mentioned configuration will now be described in detail. The guide plate 47 is penetrated by a ball screw 48a which is screw threaded to nuts 48b. The guide plate 47 can move horizontally in the direction of the arrow R1 by rotating the ball screw 48a by a motor 49. Further, a linear guide 52 is provided at the lower end of the guide plate 47 so that the lower end of the guide plate 47 does not shake when the motor 49 rotates and also the guide plate 47 can smoothly move in the direction of the arrow R1.

This configuration allows the linear guide 46 to move horizontally in the direction of the arrow R1 shown in the drawing when the guide plate 47 moves horizontally driven by the motor 49. As a result, the coupling plate 42 which is mounted to the linear guide 46 moves horizontally in the direction of the arrow R1 shown in the drawing via a linear guide 43 mounted to an elevating plate 44. Accordingly, holding claws 41a and 41b mounted to the coupling plate 42 move horizontally in the direction of the arrow R1.

Furthermore, the elevating plate 44 can move up and

down along a support plate 51, which is vertically mounted to the bottom surface of the vacuum chamber 14, via a linear guide 50. Both ends of the elevating plate 44 have rack gears 54. A drive force, provided by a motor 55, is transmitted to the rack gears 54 via a screw gear 56, a shaft 57 and a pinion gear 58 to lift and lower the elevating plates 44. Thus, the coupling plate 42 mounted to the elevating plate 44 moves up and down. That is, holding claws 41a and 41b mounted to the coupling plate 42 move up and down in the direction of the arrow R2.

Next, the configuration of the second substrate holding mechanism 60 will be described. Holding claws 61a and 61b, which are mounted to air cylinders 62a and 62b respectively, can move up and down (i.e. movement in the direction of the arrow R3 shown in FIG.4) and can rotate 90 degrees (i.e. movement in the direction of the arrow R4 shown in FIG.2). Further, it is preferable that the upper surface of the holding claws 41a, 41b and 61a, 61b is rounded so that when the holding claws come in contact with the lower surface of an upper substrate B1 they do not damage the substrate surface.

Now, referring again to FIG.1, a control apparatus 80 sends operation signals to various drive means which include a drive motor 5 through air cylinders 62a and 62b that are included in the above-mentioned stage S1,

substrate assembling section S2 and Z-axis moving stage S3. An operator of the assembling apparatus 100 determines whether to send operation signals based on the output of detection sensors (not shown) which are annexed to various drive means or measured results of alignment marks for both substrates measured by a recognition camera 24. For some portions, a sequence program (i.e. an appropriate portion of the assembly process, as will be described later, has been programmed) which has been incorporated into the control apparatus 80 is executed.

Next, the substrate assembly process executed by the above-mentioned substrate assembling apparatus will be described in detail. First, after a gate valve 16 has been opened, a substrate transfer hand of a transfer machine (not shown) installed outside the vacuum chamber 14 inserts an upper substrate B1 with its film surface faced down into the vacuum chamber 14 from the gate valve 16 side. Subsequently, the substrate transfer hand presses the upper surface of the upper substrate B1 onto the lower surface of the pressurizing plate 15 and simultaneously vacuum holds the upper substrate B1 by means of vacuum-holding ports 18a to 18c of the pressurizing plate 15. After the upper substrate B1 has been vacuum held, the substrate transfer hand is retracted to the outside of the vacuum chamber 14.

Subsequently, a motor 55 which is included in the first substrate holding mechanism 40 moves holding claws 41a and 41b to the height between the pressurizing plate 15 and the table 10, and a motor 49 moves holding claws 41a and 41b to the position where the upper substrate B1 can be accepted, and then, the substrate transfer hand located outside the vacuum chamber 14 transfers a lower substrate B2 onto the holding claws 41a and 41b. After the lower substrate B2 has been set in place, the holding claws 41a and 41b which carry the lower substrate B2 are lowered by a motor 55 to an anti claw interruption groove (not shown) which is provided on the table 10. By doing so, the lower substrate B2 is set in place on the table 10. A sealant has been applied to the peripheral portion of the upper surface of the lower substrate B2 so that it forms a frame, and a desired amount of liquid crystal has been dispensed and contained within the boundaries of the frame formed by the sealant.

After the above process has been finished, a motor 49 horizontally moves the holding claws 41a and 41b away from the table 10 and then the claws become in a stand-by mode. Further, the substrate transfer hand is retracted to the outside of the vacuum chamber 14 and then the gate valve 16 is closed.

Next, holding claws 61a and 61b are lifted by air

cylinders 62a and 62b and after being rotated 90 degrees at the ascending end, the holding claws are lowered. This mechanism allows the lower substrate B2 to be supported sandwiched by the holding claws 61a, 61b and the table 10. In such a position, the lower substrate B2 is vacuum held to the table 10 by using vacuum-holding ducts 17 provided on the table 10. The reason that the lower substrate B2 is supported sandwiched by the holding claws 61a, 61b and the table 10 is to prevent the lower substrate B2 from moving off the table 10 when a trace of air which remains between the table 10 and the lower substrate B2 is discharged in the process of reducing pressure in the vacuum chamber 14.

After the lower substrate B2 has been vacuum held to the table 10, holding claws 41a and 41b which have been in the stand-by mode at the height between the pressurizing plate 15 and the table 10 are horizontally moved and lifted until the holding claw 41a comes in contact with the lower surface of the upper substrate B1 which has been vacuum held to the pressurizing plate 15. Further, the upper substrate B1 has been horizontally vacuum held to the pressurizing plate 15 and the holding claw 41b is located lower than the holding claw 41a by the amount of "d"; therefore, at this point, the holding claw 41b does not come in contact with the lower surface of the upper substrate B1.

After the upper substrate B1 and the holding claw 41a come in contact with each other, vacuum-holding ports 18a and 18c which are located on both ends of three vacuum areas on the pressurizing plate 15 are vacuum-vented (i.e. to return to an atmospheric pressure state), and only a vacuum-holding port 18b located in the middle is providing a vacuum-holding force. By doing so, the upper substrate B1 is deflected downward due to the weight of the substrate itself and both ends of the upper substrate B1 sag, i.e., the substrate becomes convex with a mid point on the line between holding claws 41a as a center. As a result, as illustrated by broken lines in FIG.4, the gate valve 16 side peripheral portion of the upper substrate B1 can be placed on a holding claw 41b. Subsequently, the vacuum-holding port 18b located in the middle on the pressurizing plate 15 is vacuum-vented.

After the above process has been finished, the vacuum chamber 14 begins an exhausting process by using a vacuum pump connected to a duct 20 to reduce pressure in the vacuum chamber 14. After pressure reduction has started and when the vacuum condition in the vacuum chamber 14 reaches a desired pressure, electrostatic attraction between the pressurizing plate 15 and the upper substrate B1 and electrostatic attraction between the table 10 and the lower substrate B2 are executed. An appropriate degree of the

pressure reduction is the pressure at which discharge between electrostatic electrodes and substrates hardly occurs when the electrostatic force is acted on (i.e. discharge state which does not damage substrates). Because the lower substrate B2 is placed directly on the table 10, it remains on the table 10 when vacuum holding is switched to electrostatic holding. Moreover, if substrates are electrostatically held from the beginning under an atmospheric pressure without activating the electrostatic force when the pressure has been reduced to some extent as shown in this embodiment, a problem occurs that applying voltage to electrostatic chucks to make them approach substrates may cause discharge between the substrates and the electrostatic chucks, causing damages to the substrates. Therefore, in this embodiment, substrates are not held by electrostatic chucks until the pressure is reduced to a specified level.

On the other hand, because the upper substrate B1 is convex being held by claws 41a and 41b, simply activating the electrostatic force to the pressurizing plate 15 will not horizontally hold the upper substrate B1 to the pressurizing plate 15. Therefore, first, an electrostatic chuck 15b located in the middle is operated to electrostatically hold the center portion of the substrate. Subsequently, a gate valve 16 side holding claw

61a is lifted so that the sagging gate valve 16 side edge of the upper substrate B1 which has been supported by the holding claw 41b can be lifted. Thus, the holding claw 61a lifts the sagging edge of the upper substrate B1 close to the pressurizing plate 15 until the electrostatic force acts on it. After that, by applying voltage to an electrostatic chuck 15a, the gate valve 16 side edge of the upper substrate B1 can be electrostatically held to the pressurizing plate 15. Next, in the same manner as the above, the other sagging edge of the upper substrate B1, which is located on the opposite side of the gate valve 16, is lifted close to the pressurizing plate 15 by lifting a holding claw 61b until the electrostatic force acts on it. Then, voltage is applied to an electrostatic chuck 15c so that the other sagging edge of the upper substrate B1 can be electrostatically held to the pressurizing plate 15. Thus, the upper substrate B1 can be electrostatically held horizontally to the pressurizing plate 15.

In the above-mentioned upper substrate electrostatic process, if a holding claw 61b, which is located on the side on which substrate deflection is not supported by a holding claw, is lifted before a holding claw 61a has been lifted, or holding claws 61a and 61b are simultaneously lifted toward the pressurizing plate 15, the upper substrate B1 is set to be held by holding claws 41a, 61a

and 61b, however, at this point, a convex shape of the substrate is inverted to a recessed shape. As a result, the distance between the recessed portion and the pressurizing plate 15 increases, which makes it impossible for the upper substrate B1 to be electrostatically held horizontally to the pressurizing plate 15. Therefore, to avoid such inverted deflection, a holding claw 61a which is located on the same side as a holding claw 41b, is first lifted. Once an electrostatic chuck 15a has electrostatically held the gate valve 16 side edge of the upper substrate B1, when the other edge of the substrate is lifted by a holding claw 61b, the upper substrate B1 is not deformed into such a shape as described above, and the upper substrate B1 can be held horizontally to the pressurizing plate 15.

Moreover, in the above-mentioned electrostatic process, voltage is sequentially applied to each electrostatic chuck 15a to 15c. However, it is possible to apply voltage to electrostatic chucks 15a and 15c at the same time when voltage is applied to an electrostatic chuck 15b because the upper substrate B1 is convex being by holding claws 41a, 41b and also the electrostatic force does not act on the sagging edges but only on the center portion of the substrate.

As described above, after the upper substrate 81 has

been electrostatically held to the pressurizing plate 15 and the lower substrate B2 has been electrostatically held on the table 10, holding claws 61a and 61b are rotated and retracted from the substrate surface, and also holding claws 41a and 41b are horizontally moved away from the substrate surface, and then the claws enter into a stand-by mode.

Under the above condition, an electrical motor 30 lowers a Z-axis direction moving base 27 to make the upper substrate B1 approach the lower substrate B2. At this point, a recognition camera 24 detects alignment marks which are provided on the upper and the lower substrates B1 and B2 and measures the dislocation of the substrates' positions. Based on the obtained measurements, the stage S1 is controlled. The upper substrate B1 and lower substrate B2 are panel aligned by moving the lower substrate B2 by a desired amount so that the upper substrate B1 and the lower substrate B2 are accurately affixed.

After the panel alignment has been made, the Z-axis direction moving base 27 is further lowered so that the upper substrate B1 is stacked on the lower substrate B2 to which a sealant has been applied. Subsequently, the substrates which contain liquid crystal therebetween within the boundaries of the frame formed by the sealant are affixed. Further, to avoid the dislocation of the

upper substrate B1 and the lower substrate B2 after they have been affixed, it is recommended that a photosetting adhesive be applied spottedly to the film surface of the substrate.

After the above-mentioned assembly process has been completed, voltage application to the electrostatic chucks 15a to 15c of the pressurizing plate 15 is stopped, the Z-axis direction moving base 27 is lifted, and then voltage application to the electrostatic chucks of the table 10 is stopped, and finally a vent switching valve 22 is opened to vent the vacuum chamber 14 so that it returns to atmospheric pressure.

After the pressure of the vacuum chamber 14 has reached atmospheric pressure, the gate valve 16 is opened and vacuum-holding ports 17 of the table 10 are opened. Then, holding claws 41a and 41b lift the cell, and then the substrate transfer hand of the transfer machine (not shown) is inserted under the cell to transfer the cell onto it, and finally the substrate transfer hand is retracted so as to unload the cell from the vacuum chamber 14.

When the state of the vacuum chamber 14 returns to atmospheric pressure from a vacuum, an airflow may occur in the vacuum chamber 14 which may result in the cell being moved on the table 10. If the cell has been moved on the table 10, even though the holding claws 41a and 41b are

attempted to lift the cell to transfer it onto the substrate transfer hand, it is impossible for the cell to be lifted because it has moved away from the holding claws 41a and 41b. Therefore, when the vacuum chamber 14 is vented and returns to atmospheric pressure, it is recommended that the cell be lightly supported sandwiched by holding claws 61a, 61b and the table 10, which have been retracted, so as to prevent the cell from moving.

As described above, a substrate assembling method and a substrate assembling apparatus in accordance with the present invention can make it possible to accurately assemble long-lived substrates without putting a strain on the substrates even when the size of a substrate is increased or the thickness is reduced.

FIG.5 illustrates another embodiment of the present invention. FIG.6 is a cross-sectional view (i.e. a drawing seen from the C section) of a vacuum chamber shown in FIG.5.

The difference between this embodiment and the previously-mentioned embodiment is that this embodiment has a third substrate holding mechanism 70 in addition to a first substrate holding mechanism 40 and a second substrate holding mechanism 60. Further, a first substrate holding mechanism 40 has additional holding claws 41c. The third substrate holding mechanism 70 is configured as described below. Holding claws (holding

bodies) 71 are mounted to the edges of the table 10 at four locations (it is preferable that the third substrate holding mechanism 70 is provided at four locations or more). A holding claw 71 is mounted to a shaft 76 via a motor 74, which is mounted to a metal fixture 73 of an elevating cylinder 72 mounted to the lower surface of the vacuum chamber 14, and a coupling 75. The holding claw 71 moves up and down in response to the R5 direction movement of the cylinder 72. Furthermore, the holding claw 71 can move in an arbitrary angle in the direction of R7 driven by the motor 74, and the rotation angle can be set so that the tip of the holding claw 71 does not come in contact with a sealant provided on a substrate. For example, when a sealant has been applied to a substrate so that nine panels can be produced from the substrate, the rotation angle can be set at a position between locations where the sealant is applied.

Furthermore, this embodiment has a third substrate holding mechanism 70 each at four corners of the upper and lower tables, and by having a plurality of it, the flatness of a substrate can be highly maintained thereby increasing the electrostatic force. Moreover, providing the third substrate holding mechanism 70 allows the center portion of the substrate to be easily held in a convex shape. This makes it more effective to activate an electrostatic force

on the center portion of the substrate to hold it without it being strained. In other words, by moving the third holding mechanism 70 to hold the substrate so that the center portion of the substrate becomes convex and simultaneously holding it by means of the first and second substrate holding mechanisms 40 and 60 at a position lower than the third substrate holding mechanism, the same result as in the first embodiment can be obtained. At this point, the holding claw 40b located in the middle can be higher than holding claws 40a and 40c provided in the first substrate holding mechanism 40 or they can also be at the same height.

[WHAT IS CLAIMED IS]

[Claims 1]

An apparatus for assembling substrates comprising a vacuum chamber, a table on which a substrate to be affixed is placed in the vacuum chamber, and a pressurizing plate which vacuum holds a counter substrate to be affixed facing to said substrate and presses it onto said substrate below, wherein

said pressurizing plate comprises a mechanism that vacuum holds said counter substrate until the pressure in the vacuum chamber is reduced to a specified pressure from atmospheric pressure before both substrates are affixed, and a mechanism that electrostatically holds said counter substrate in a low pressure state where the gap between the substrates is narrowed and finally the substrates are affixed;

a first substrate holding mechanism that holds two opposed edges of the counter substrate and a second substrate holding mechanism that holds remaining two opposed edges of the counter substrate are provided to mechanically hold the peripheral portions of said counter substrate in order to prevent said counter substrate from falling onto said substrate below as the vacuum holding force decreases; and

the height of holding claws located in central portions among a plural holding claws located in said

first substrate holding mechanisms is set to be higher than any other holding claws located in said first substrate holding mechanisms.

[Claims 2]

An apparatus for assembling substrates according to Claim 1, further comprising a third substrate holding mechanism which holds the vicinity of the *center portion* of said counter substrate in addition to said first and second substrate holding mechanisms which hold the peripheral portions of said counter substrate.

[Claims 3]

An apparatus for assembling substrates comprising a vacuum chamber, a table on which a substrate to be affixed is placed in the vacuum chamber, and a pressurizing plate which vacuum holds a counter substrate to be affixed facing to said substrate and presses it onto said substrate below, wherein

said pressurizing plate comprises a mechanism that vacuum holds said counter substrate until the pressure in the vacuum chamber is reduced to a specified pressure from atmospheric pressure before both substrates are affixed, and a mechanism that electrostatically holds said counter substrate in a low pressure state where the gap between

the substrates is narrowed and finally the substrates are affixed;

a first substrate holding mechanism that holds two opposed edges of the substrate and a second substrate holding mechanism that holds remaining two opposed edges of the substrate are provided to mechanically hold the peripheral portions of said counter substrate in order to prevent said counter substrate from falling onto said substrate below as the vacuum holding force decreases; and

the height of holding claws located in central portions among a plural holding claws located in said first substrate holding mechanism is set to be the same as any other holding claws located in said first substrate holding mechanism.

[Claims 4]

A method of assembling substrates which places a substrate on a table located on the underside of a vacuum chamber, electrostatically holds a counter substrate to be affixed with said substrate to a pressurizing plate facing said substrate placed on said table in a vacuum chamber, and narrows the gap between said substrates in a vacuum to affix said substrates together by means of an adhesive provided on either substrate, whereby the entire surface of said counter substrate is initially vacuum held to said

pressurizing plate under atmospheric pressure, the middle portions of a pair of opposite sides of said counter substrate are mechanically held, the vacuum holding of the middle portions of said pair of opposite sides is released after the vacuum holding of other opposite sides has been released to make the sides become free, and when the pressure in the vacuum chamber is reduced to a desired pressure, voltage is applied to said pressurizing plate to electrostatically hold the middle portions of said pair of opposite sides of said counter substrate, and sequentially other free edges are electrostatically held, thereby the entire surface of said counter substrate being electrostatically held to said pressurizing plate facing said substrate below.

[Claims 5]

A method of assembling substrates according to Claim 4, whereby after one free edge of a pair of opposite sides of said counter substrate has been mechanically held at a location lower than the position where the middle portion is being held, the vacuum holding of the middle portions of said pair of opposite sides of said counter substrate is released.

[Claims 6]

A method of assembling substrates according to Claim 4, whereby each free edge of said counter substrate is lifted to a location where an electrostatic attraction force provided by said pressurizing plate becomes active so that each free edge can be electrostatically held to said pressurizing plate.

[Claims 7]

An apparatus for assembling substrates which places a substrate on a table located on the underside of a vacuum chamber, electrostatically holds a counter substrate to be affixed with said substrate to a pressurizing plate facing said substrate placed on said table in a vacuum chamber, and narrows the gap between said substrates in a vacuum to affix said substrates together by means of an adhesive provided on either substrate, comprising

means for vacuum holding the entire surface of said counter substrate to said pressurizing plate under atmospheric pressure,

means for mechanically holding the middle portions of a pair of opposite sides of said counter substrate,

means for releasing the vacuum holding of the middle portions of said pair of opposite sides after the vacuum holding of other opposite sides of said counter substrate has been released to make the edges free,

means for applying voltage to said pressurizing plate

for electrostatic attraction when the vacuum state of the vacuum chamber becomes a desired vacuum level, and

means for electrostatically holding the entire surface of said counter substrate to said pressurizing plate by electrostatically holding the middle portions of said pair of opposite sides of said counter substrate to said pressurizing plate and then electrostatically holding other free edges of said counter substrate sequentially.

[Claims 8]

An apparatus for assembling substrates according to Claim 7, wherein said pressurizing plate comprises means for individually vacuum holding the middle portions of said pair of opposite sides of said counter substrate and means for individually vacuum holding other opposite sides of said counter substrate.

REPLACEMENT SHEET

10 JUL 2002

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METHOD AND APPARATUS FOR ASSEMBLING SUBSTRATE

[NAME OF DOCUMENT] ABSTRACT OF THE DISCLOSURE

[Abstract]

[Subject]

An apparatus for assembling substrates comprising a pressurizing plate which holds a counter substrate directly above a table facing a substrate placed on the table, wherein said pressurizing plate comprises vacuum holding means which allows individual control of a plurality of vacuum-holding areas and electrostatically holding means which also allows individual control of a plurality of electrostatically holding areas; the entire surface of said counter substrate is vacuum held under atmospheric pressure; and substrate holding mechanisms are provided so that the middle portions of a pair of opposite sides of said counter substrate can be mechanically held at a higher location than the peripheral portions when the vacuum-holding force in the vacuum chamber decreases.

Figure 1

FIG. 1

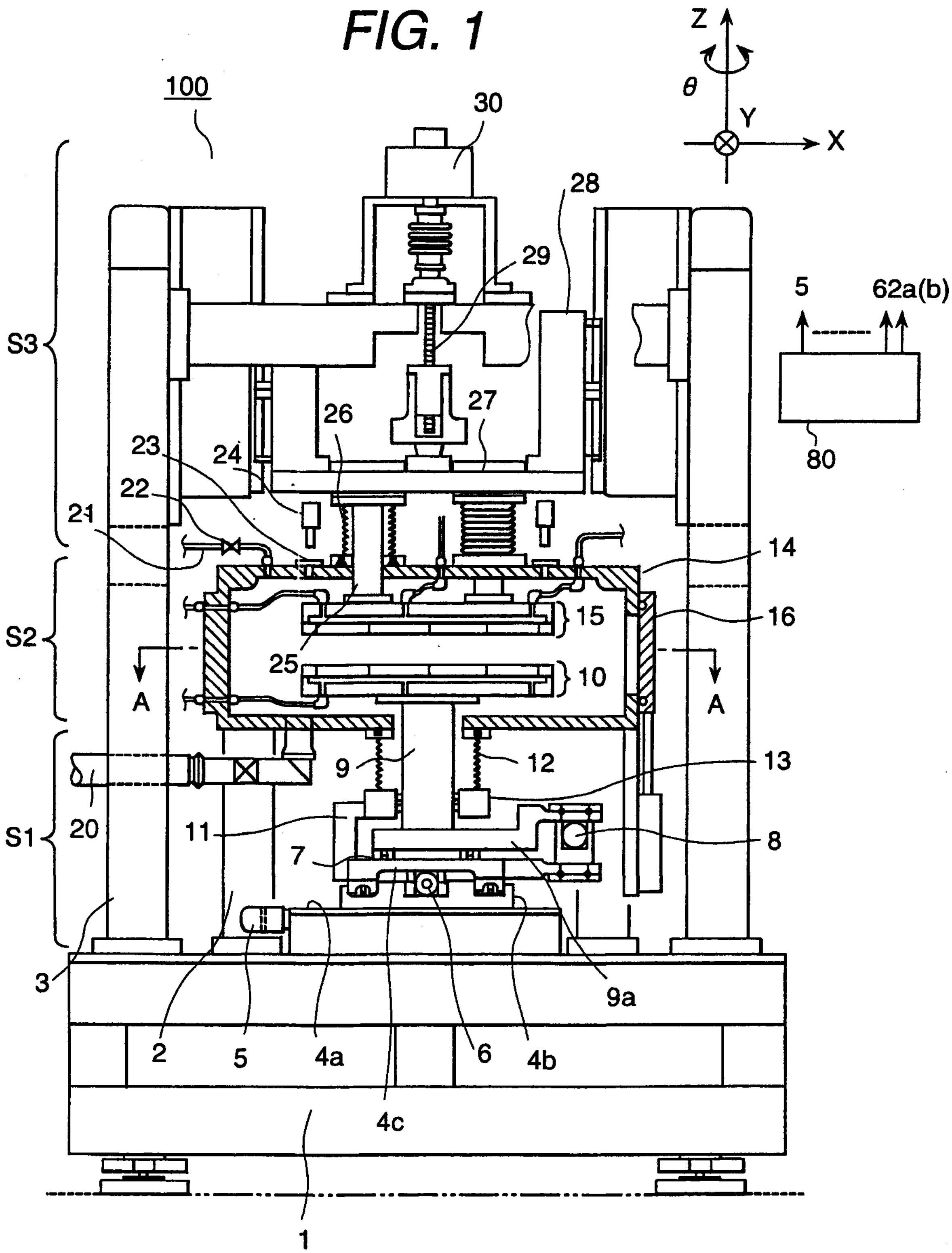

Z
θ
Y
X
100
30
28
29
5
62a(b)
80
S3
26
27
23
24
22
21
14
S2
15
16
25
10
A
A
S1
20
9
12
13
11
8
7
3
2
5
4a
6
4b
9a
4c
1

FIG. 2

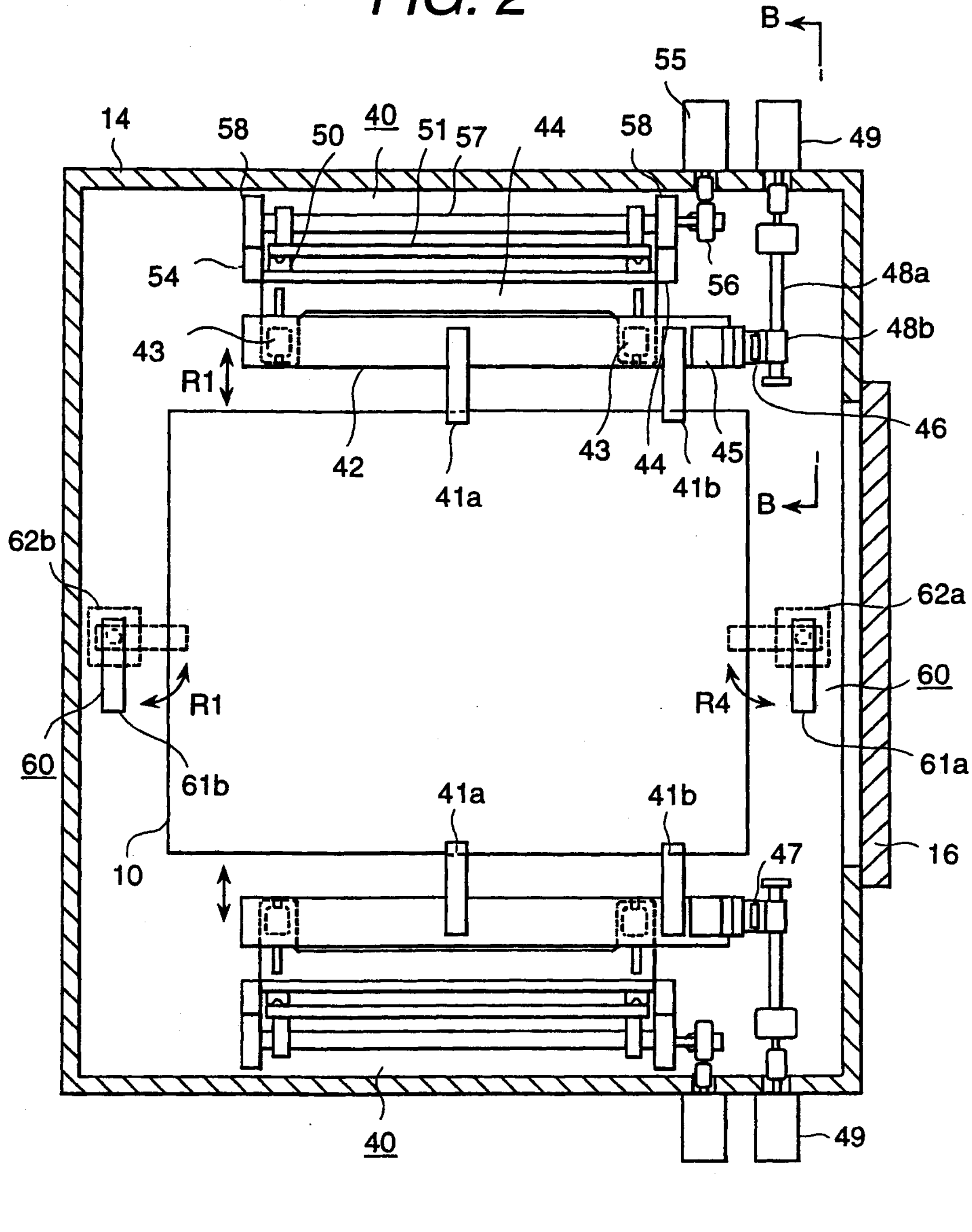
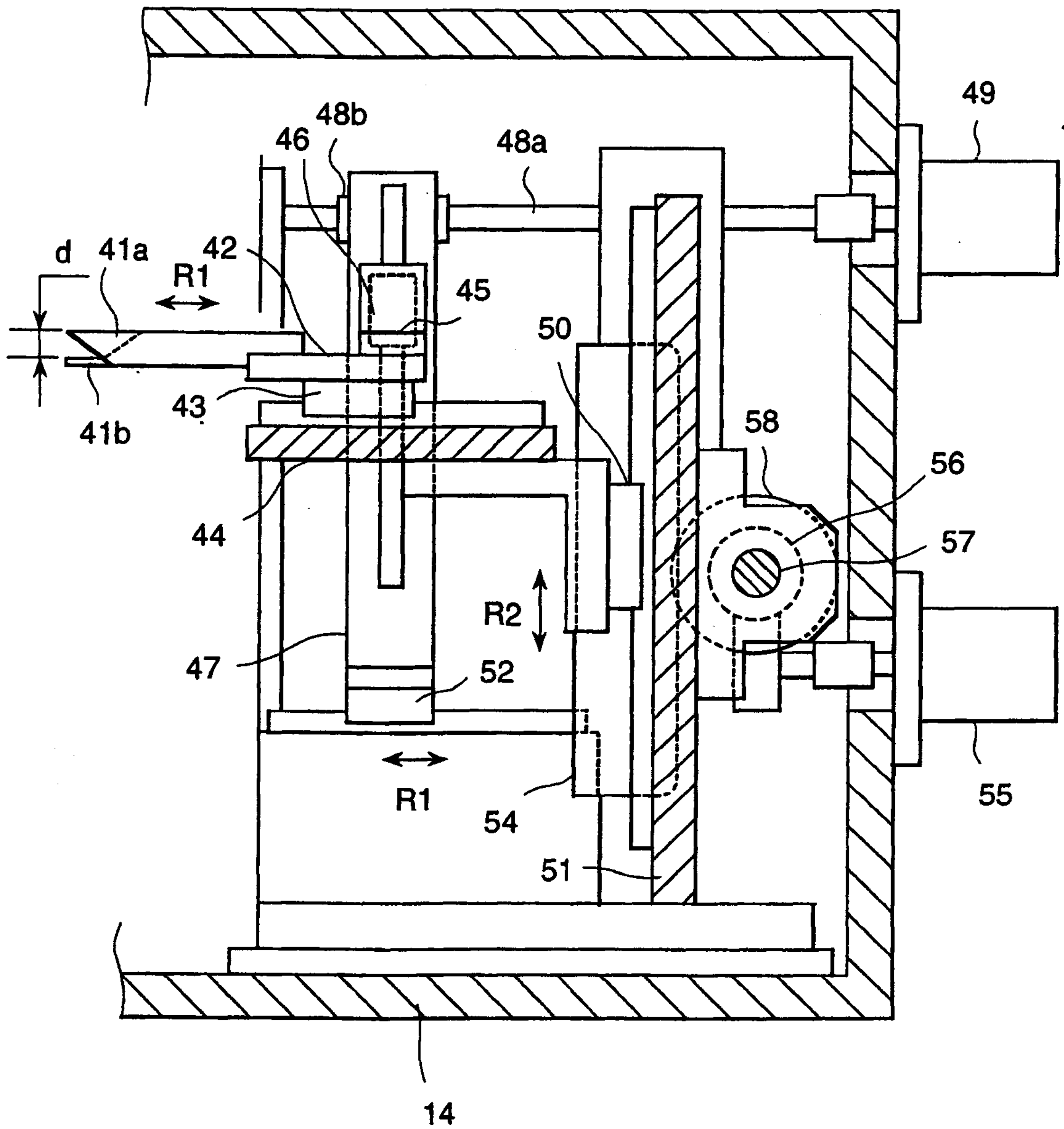

B
55
49
14
58
50
40
51
57
44
58
54
56
48a
48b
43
R1
46
42
41a
43
44
45
41b
B
62b
62a
60
R1
R4
60
61a
61b
41a
41b
47
10
16
40
49

FIG. 3



d
41a
R1
42
46
48b
48a
49
45
50
43
41b
44
58
56
57
R2
47
52
R1
54
51
55
14

FIG. 4

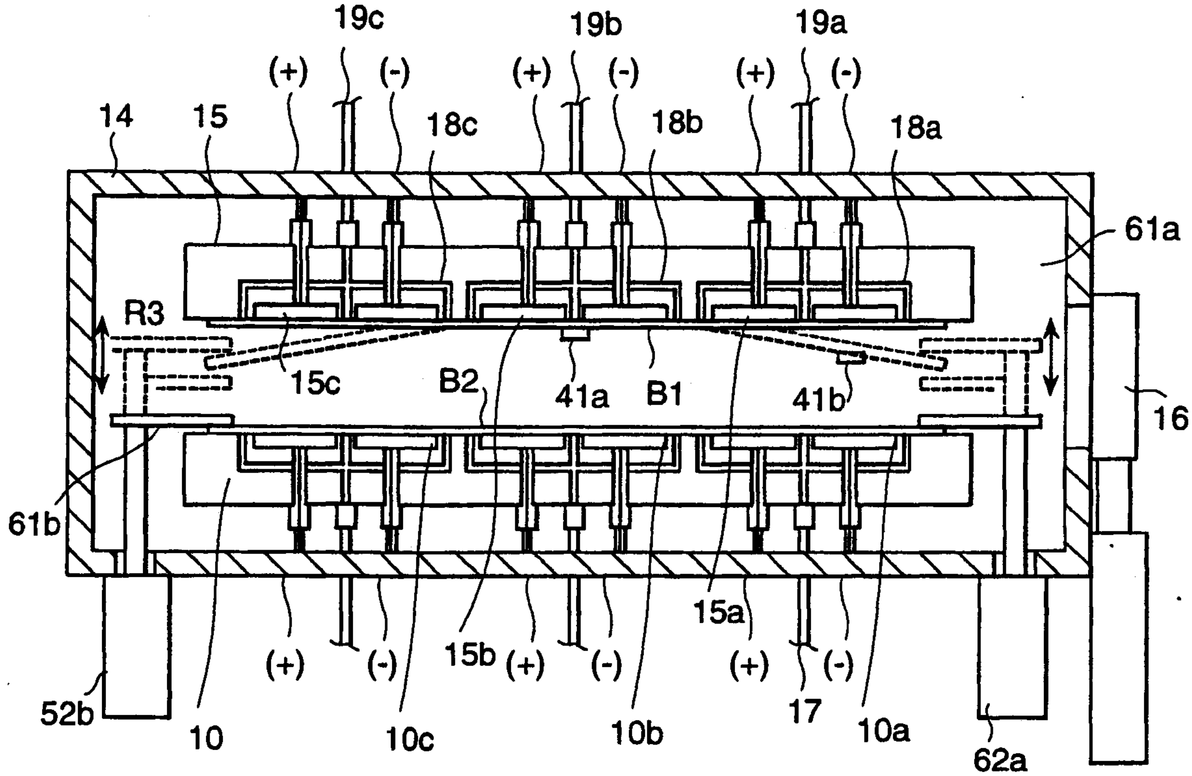

19c
19b
19a
(+)
(-)
14
15
18c
18b
18a
61a
R3
15c
B2
41a
B1
41b
16
61b
15a
15b
17
52b
10
10c
10b
10a
62a

FIG. 6

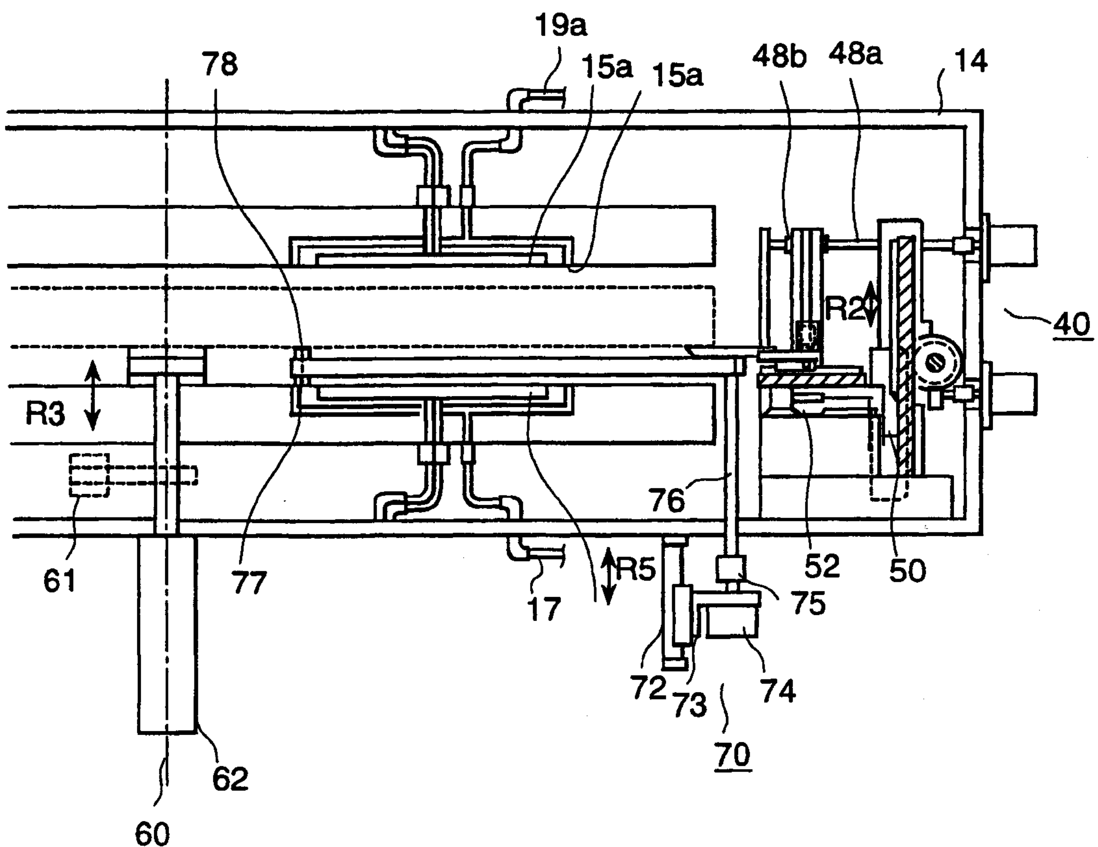
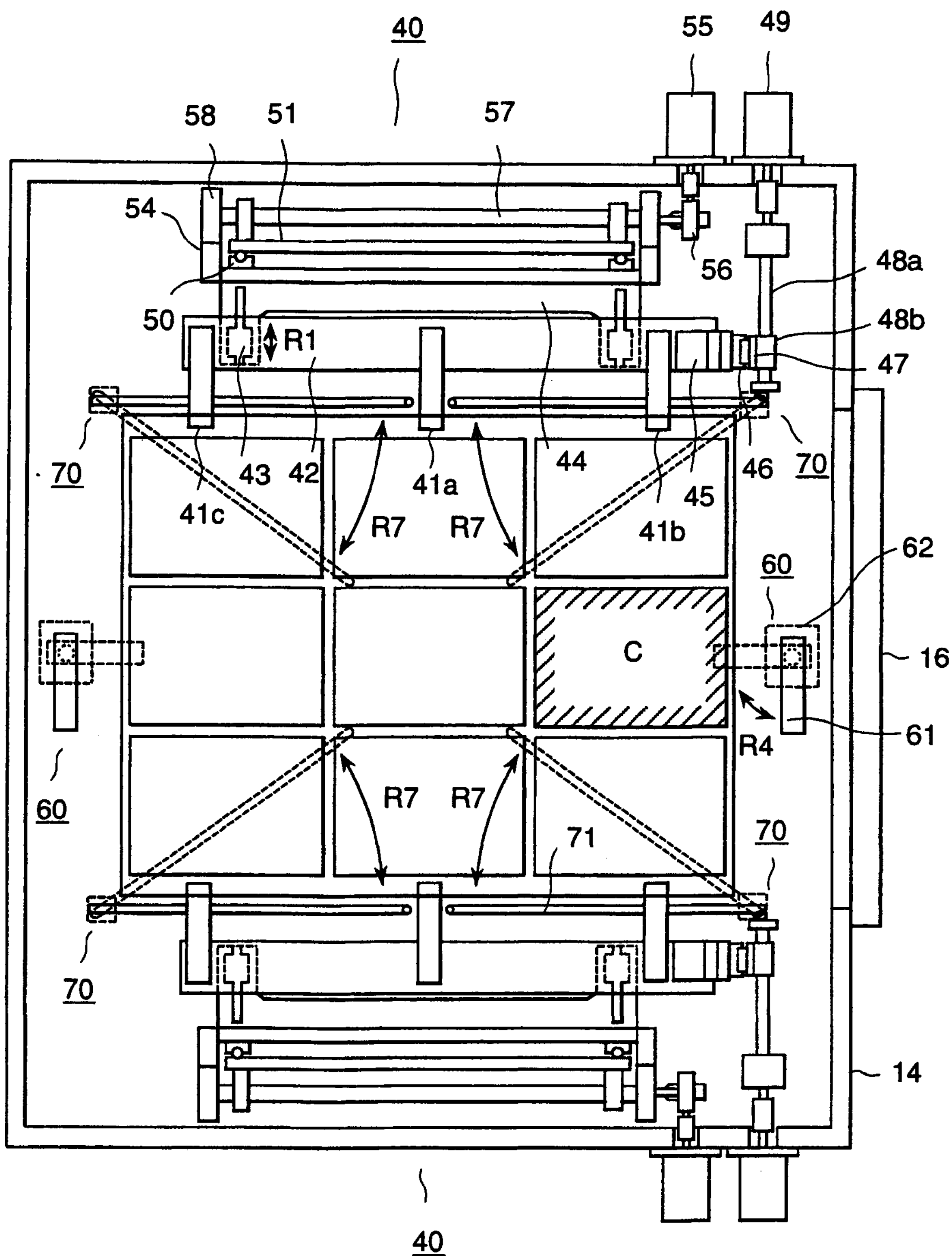

19a
78
15a
15a
48b
48a
14
R2
40
R3
76
61
77
17
R5
52
50
75
72
73
74
70
62
60

FIG. 5


40
55
49
58
51
57
54
56
48a
50
48b
R1
47
70
43
42
41a
44
46
70
41c
R7
R7
45
41b
62
60
C
16
61
R4
60
R7
R7
71
70
70
14
40